International Journal of Environment and Climate Change

Volume 13, Issue 8, Page 761-770, 2023; Article no.IJECC.100833
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Response of Different Levels of NPK and Zinc on Soil Health in Black Gram (*Vigna mungo* L.)

Anju Choudhary [a*], Narendra Swaroop [a], Tarence Thomas [a] and Taniya Mistri [a]

[a] Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj- 211007, U. P., India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i82008

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/100833

Original Research Article

Received: 28/03/2023
Accepted: 31/05/2023
Published: 05/06/2023

ABSTRACT

An experiment was conducted during in *Zaid* season (March 2022-June 2022) to study the "effect of different levels of NPK and Zinc on soil health in black gram (*Vigna mungo* L.)" on central research farm of Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. A randomized block design was used to set up the experiment, with three levels of NPK (0%, 50%, and 100% NPK) and three levels of zinc (0%, 50%, and 100% zinc). The outcome demonstrates that inorganic fertilizer application had a non-significant effect on soil physical-chemical parameters (BD, PD, pH, EC and OC) and significant increase in pore space, water holding capacity, available nitrogen, phosphorus, potassium and zinc in treatment T_9 [NPK at 100% + zinc at 100%] than other treatments.

Keywords: NPK; physical; chemical properties; soil health; zinc.

**Corresponding author: E-mail: anjuchoudhary5432@gmail.com*

1. INTRODUCTION

A natural body made up of solids (minerals and organic matter), liquid, and gases, soil is defined as "a natural body that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter, or the ability to support rooted plants in a natural environment." As per the United States Department of Agriculture (USDA).

Fertilizers containing nitrogen are crucial for raising crop productivity and enhancing soil fertility. The crop's biomass and grain production rise when nitrogen fertilizer is used. It increases the soil's residual N by 18 to 34%. The effects of sole residue integration or combination with N fertilizer on plant development and production as well as the Physico-chemical properties of the soil are favorable. A crucial component that plants need is nitrogen. It enhances the amount of protein in pulses and the growth and development of all biological tissues. The synthesis of amino acids, chlorophyll, and other organic chemicals that serve as the building blocks of proteins as well as promoting plant growth make nitrogen one of the most important nutrients (Sarvsade et al., 2019); [1,2].

One of the three main macronutrients that plants need for the greatest growth and development is phosphorus (P), which is a crucial nutrient element. Photosynthesis, respiration, energy storage, root growth, cell elongation, and crop quality are all impacted by phosphorus. Plants with deficiencies may have erect, thin stems that are wiry, and their leaves may turn a bluish green tint. The growth of root nodules is boosted, and Rhizobium activity is improved. As a result, it aids in the root nodules' ability to fix more nitrogen from the atmosphere [1].

It has been said that potassium is a "quality element" and a "master cation" that is essential for the growth and development of the plant. Numerous crucial enzymes, including those involved in protein synthesis, sugar transport, disease resistance, drought tolerance, N and C metabolism, and photosynthesis, are activated by it. Potassium is crucial for improving quality and raising output [3-6].

The most deficient micronutrient in Indian soils is zinc, which is also considered to be the third-most crucial component for crop productivity after nitrogen and phosphorus. Due to zinc's significant effects on yield qualities and its significance in metabolic processes, the rise in yield may be explained by these factors. According to Hafeez Z et al. [7], zinc contributes to the synthesis of auxin, the activation of dehydrogenase enzymes, and the stabilization of ribosomal fractions.

2. MATERIALS AND METHODS

A field experiment to study the Effect of Different Levels of NPK and Zinc on Soil Health in Black Gram (*Vigna mungo* L.) was conducted at central research farm department of Soil Science and Agricultural Chemistry, SHUATS, Prayagraj. This area normally falls under the subtropical belt in the southeast of Uttar Pradesh, where the summers are quite hot and the winters are moderately chilly. The location's highest temperature occasionally drops below 4^0C or 5^0C and can reach up to 46^0C to 48^0C. Between 20 to 94% the relative humidity was present. Around 1100 mm of rain precipitation occurs yearly on average in this region. The experimental site is located 98 meters above sea level at 25^0 57'N latitude and 81^0 59'E longitude. The soil in the experimental region is classified as Inceptisol, and its texture is sandy loam (sand content: 62.71%; silt content: 23.10%; clay content: 14.1%). The experiment was set up using a randomized block design (RBD), which included nine treatments and three doses of NPK (0, 50, and 100%) and Zn (0, 50, and 100%). Three replicates of the treatment have been made. There were 27 plots in total. Black gram sowing in 2 x 2 m plots during the *Zaid* season, with a spacing of 30 x 10 cm. Soil samples were taken from each plot both before and after the experiment at a depth of 0-15 to 15–30 cm by using a soil auger. The soil samples were air-dried, put through a 2 mm screen, and then had their different soil qualities examined. M.L. Jackson [8] assessed the soil pH with a pH meter, and Wilcox [9] measured the electrical conductivity (EC) with a conductivity meter. The available nitrogen (N) was calculated using the Subbiah and Asija method (1956), the phosphorus (P) was calculated using the Olsen et al. method (1954), the potassium (K) was calculated using the Toth and Prince method (1949), and the zinc (Zn) was estimated using the Lindsay and Norvell method [10]. The soil organic carbon (SOC) was estimated using the Walkley and Black method [11].

3. RESULTS AND DISCUSSION

3.1 Physical Properties

3.1.1 Bulk density (Mg m^{-3})

The response on the soil bulk density found to be non-significant. The maximum bulk density of soil was found 1.288 Mg m^{-3} and 1.296 Mg m^{-3} in treatment T_9 (NPK @ 100% + Zn @ 100%) and the minimum was 1.243 Mg m^{-3} and 1.250 Mg m^{-3} found at soil depths of 0-15 and 15-30 cm in treatment T_1 (NPK @ 0 % + Zn @ 0 %) respectively. It was also observed the bulk density of soil was gradually increased with an increase in dose of different levels of NPK and Zn. Similar result has been recorded by Kumar et al*.,* [12]; Bhattacharya et al*.,* [13].

3.1.2 Particle density (Mg m^{-3})

The mean value of particle density of soil (Mg m^{-3}) was found non-significant. The maximum particle density was 2.518 Mg m^{-3} and 2.526 Mg m^{-3} found in T_9 (NPK @ 100 % + Zn @ 100 %) and minimum was 2.475 Mg m^{-3} and 2.482 Mg m^{-3} found at soil depths of 0-15 and 15-30 cm in treatment T_1 (NPK @ 0% + Zn @ 0%) respectively. It was also observed the particle density of soil was gradually increased with an increase in dose of different levels of NPK and Zn. Similar result has been recorded by Hussain et al., [14]; Dangi et al., [15].

3.1.3 Pore space (%)

The response pore space of soil was found to be significant in levels of NPK and Zn. The maximum pore space of soil was recorded 46.58 % and 42.27 % found in T_9 (NPK @ 100% + Zn @ 100 %) and minimum pore space of soil was recorded 41.60 % and 37.42 % fond at soil depths of 0-15 and 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0 %)] respectively. It was also observed the pore space of soil was gradually increased with an increase in dose of different levels of NPK and Zn. Similar result has been recorded by; Azadi et al., [16]: Amurta et al., [17].

3.1.4 Water holding capacity (%)

The response water holding capacity of soil was found to be significant in levels of NPK and Zn. The maximum water holding capacity of soil was recorded 40.26 % and 38.71 % found in treatment T_9 (NPK @ 100% + Zn @ 100 %) and minimum water holding capacity of soil was recorded 34.55 % and 32.48 % founds at of depths 0-15 to 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0 %)] respectively. It was also observed the water holding capacity (%) of soil was gradually increased with an increase in dose of different levels of NPK and Zn. Similar result has been recorded by Azadi et al., [16]: Amurta et al., [17].

3.2 Chemical Properties

3.2.1 Soil pH (1:2.5)

The response pH of soil was found to be non-significant in levels of NPK and Zn. The maximum pH of soil was recorded 7.06 and 7.14 founds in treatment T_9 (NPK @ 100% + Zn @ 100 %) and minimum pH of soil was recorded 6.50 and 6.56 found at of depths 0-15 to 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0 %)] respectively. It was also observed the pH of soil was gradually increased with an increase in dose of different levels of NPK and Zn. Similar result has been recorded by Chandrakar, [18]: Jha et al., [19].

3.2.2 Soil EC (dS m^{-1})

The response EC of soil was found to be non-significant in levels of NPK and Zn. The maximum EC of soil was recorded 0.474 dS m^{-1} and 0.480 dS m^{-1} founds in treatment T_9 (NPK @ 100% + Zn @ 100 %) and minimum EC of soil was recorded 0.442 dSm^{-1} and 0.446 dS m^{-1} found at of depths at 0-15 to 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0 %)] respectively. It was also observed that EC of soil were gradually increased with increasing dose of NPK and Zn. Similar result has been recorded by Meena and Ram, [20]; Habib et al*.,* [21].

3.2.3 Organic carbon (%)

The maximum organic carbon of soil was found 0.407 and 0.396 in T_9 (NPK @ 100 % + Zn @ 100 %) and minimum was measured 0.375 and 0.368 % at soil depths 0-15 and 15-30 cm in treatment T_1 (NPK @ 0 % + Zn @ 0 %) respectively. It was also observed that organic carbon of soil was gradually increased with increasing dose of NPK and Zn. Similar result has been recorded by Meena and Ram, [20]; Habib et al*.,* [21].

3.2.4 Available nitrogen (kg ha^{-1})

The response Available Nitrogen of soil was found to be significant in levels of NPK and Zn. The maximum Available Nitrogen of soil was

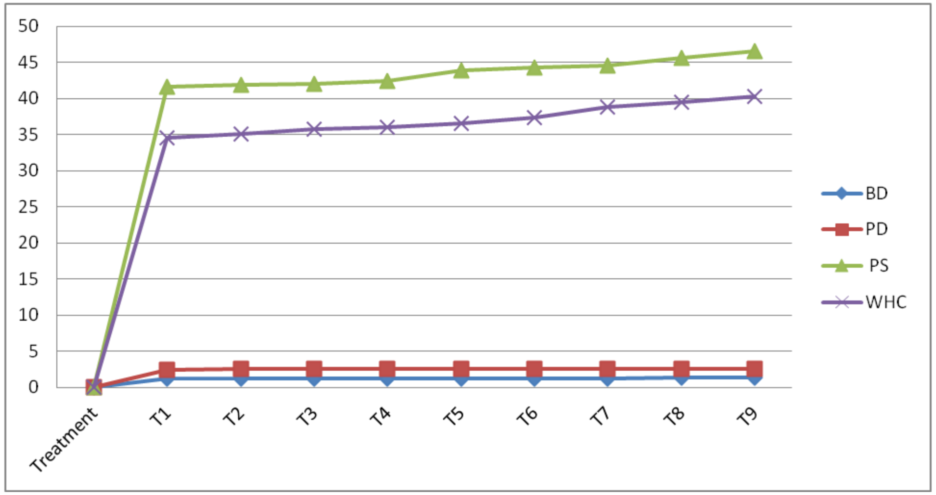

Fig. 1. Effect of different levels of NPK and Zn on BD (Mg m^{-3}), PD (Mg m^{-3}), PS (%), and WHC (%) of soil depth (0-15 cm)

Table 1. Effect of NPK and Zn on soil physical properties

Treatment	BD (Mg m^{-3})		PD (Mg m^{-3})		Pore space (%)		Water holding capacity (%)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
NPK @ 0 % + Zn @ 0 %	1.243	1.250	2.475	2.482	41.60	37.42	34.55	32.48
NPK @ 0 % + Zn @ 50 %	1.248	1.255	2.480	2.487	41.86	37.60	35.07	33.60
NPK @ 0 % + Zn @ 100 %	1.254	1.262	2.486	2.492	42.08	38.15	35.76	35.18
NPK @ 50 % + Zn @ 0 %	1.260	1.268	2.490	2.497	42.42	39.08	36.04	35.26
NPK @ 50 % + Zn @ 50 %	1.265	1.274	2.495	2.504	43.88	39.72	36.61	35.92
NPK @ 50 % + Zn @ 100 %	1.272	1.278	2.501	2.509	44.22	40.52	37.30	36.22
NPK @ 100 % + Zn @ 0 %	1.276	1.285	2.507	2.515	44.61	41.18	38.84	36.09
NPK @ 100 % + Zn @ 50 %	1.282	1.290	2.512	2.520	45.60	41.56	39.51	37.85
NPK @ 100 % + Zn @ 100 %	1.288	1.296	2.518	2.526	46.58	42.27	40.26	38.71
F-Test	NS	NS	NS	NS	S	S	S	S
S.Ed. (±)	-	-	-	-	0.62	0.48	0.68	0.55
C.D. at 0.5%	-	-	-	-	1.32	0.99	2.06	1.65

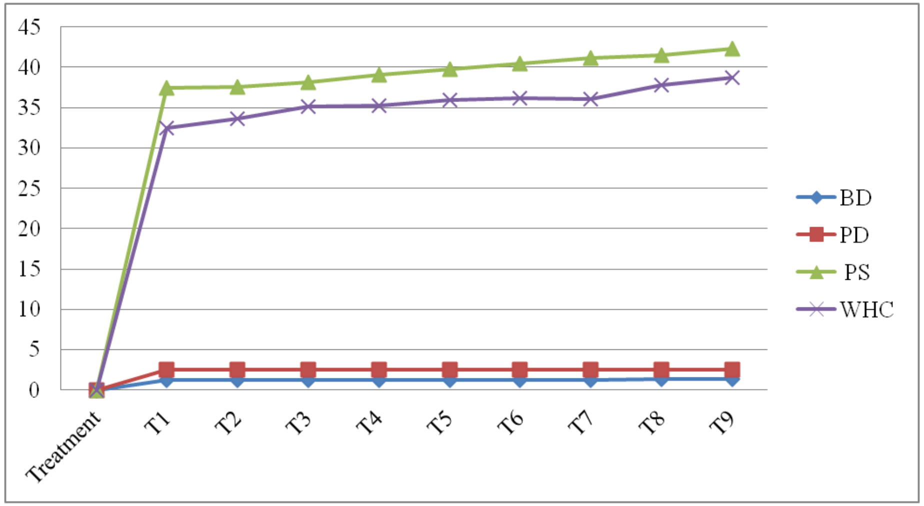

Fig. 2. Effect of different levels of NPK and Zn on BD (Mg m^{-3}), PD (Mg m^{-3}), PS (%), and WHC (%) of soil depth (15-30 cm)

Table 2. Effect of NPK and Zn on soil chemical properties

Treatment	pH		EC (dS m^{-1})		Organic carbon (%)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
NPK @ 0 % + Zn @ 0 %	6.50	6.56	0.442	0.446	0.375	0.368
NPK @ 0 % + Zn @ 50 %	6.57	6.62	0.447	0.449	0.380	0.372
NPK @ 0 % + Zn @ 100 %	6.64	6.68	0.451	0.453	0.384	0.376
NPK @ 50 % + Zn @ 0 %	6.70	6.75	0.454	0.456	0.389	0.379
NPK @ 50 % + Zn @ 50 %	6.76	6.82	0.458	0.463	0.392	0.381
NPK @ 50 % + Zn @ 100 %	6.81	6.86	0.462	0.467	0.395	0.386
NPK @ 100 % + Zn @ 0 %	6.89	6.91	0.465	0.471	0.398	0.390
NPK @ 100 % + Zn @ 50 %	6.94	6.97	0.470	0.475	0.403	0.393
NPK @ 100 % + Zn @ 100 %	7.06	7.14	0.474	0.480	0.407	0.396
F-Test	NS	NS	NS	NS	NS	NS
S.Ed. (±)	-	-	-	-	-	-
C.D. at 0.5%	-	-	-	-	-	-

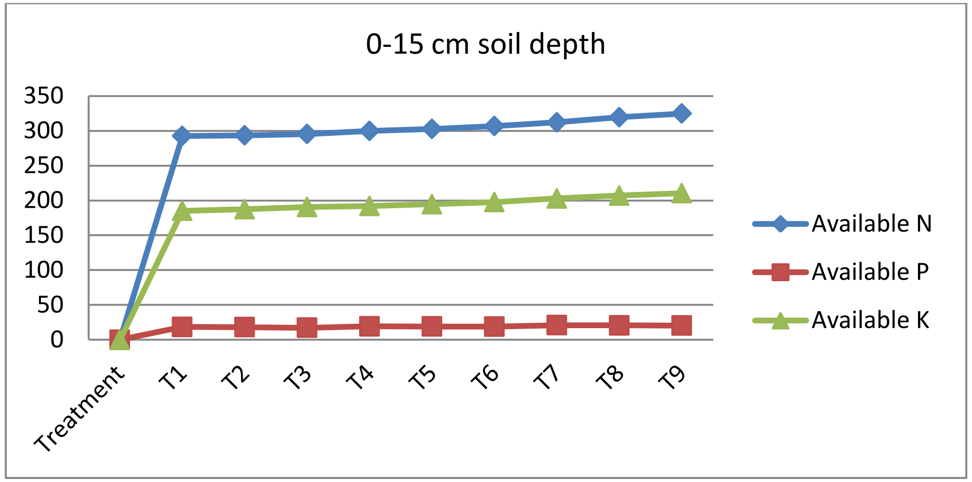

Fig. 3. Effect of different levels of NPK and Zn on Available N (kg h^{-1}), P (kg h^{-1}), and K (kg h^{-1}), of soil depth (0-15 cm

Table 3. Effect of NPK and Zn on soil chemical properties

Treatment	Available Nitrogen (kg ha^{-1})		Available Phosphorus (kg ha^{-1})		Available Potassium (kg ha^{-1})		Available Zinc (mg kg^{-1})	
	0-15 cm	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**
NPK @ 0 % + Zn @ 0 %	292.61	288.34	18.41	17.45	185.24	181.56	0.288	0.290
NPK @ 0 % + Zn @ 50 %	293.47	289.06	18.17	17.31	187.42	184.80	0.340	0.352
NPK @ 0 % + Zn @ 100 %	295.38	291.88	17.36	16.85	190.59	187.52	0.354	0.359
NPK @ 50 % + Zn @ 0 %	299.70	293.62	19.23	18.12	192.10	189.77	0.326	0.332
NPK @ 50 % + Zn @ 50 %	302.64	296.29	19.14	17.96	194.54	191.89	0.348	0.337
NPK @ 50 % + Zn @ 100 %	306.82	300.50	18.87	17.08	197.70	194.42	0.336	0.343
NPK @ 100 % + Zn @ 0 %	312.04	306.23	21.03	20.89	202.83	198.61	0.320	0.347
NPK @ 100 % + Zn @ 50 %	319.32	312.35	20.61	19.86	206.97	202.56	0.328	0.324
NPK @ 100 % + Zn @ 100 %	324.78	318.56	20.47	19.43	210.45	206.72	0.343	0.329
F-Test	S	S	S	S	S	S	S	S
S.Ed. (±)	2.18	1.80	1.10	0.68	1.75	1.41	0.12	0.15
C.D. at 0.5%	4.42	3.62	2.23	1.40	3.28	1.85	0.27	0.32

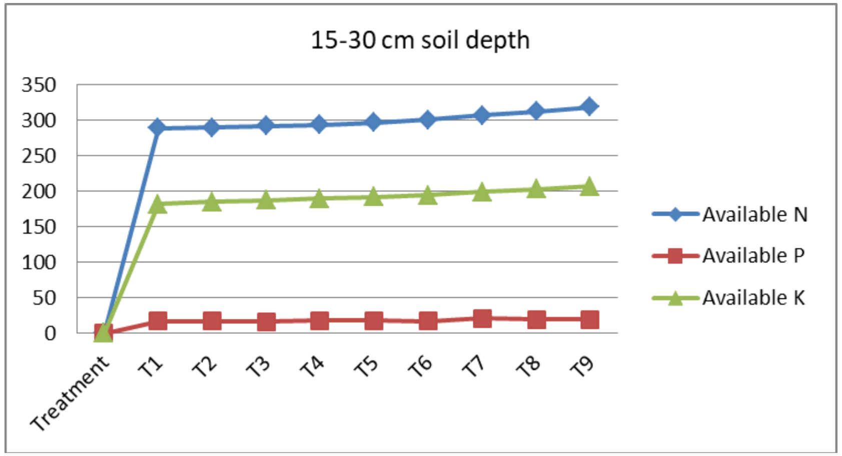

Fig. 4. Effect of different levels of NPK and Zn on Available N (kg h^{-1}), P (kg h^{-1}), and K (kg h^{-1}), of soil depth (15-30 cm)

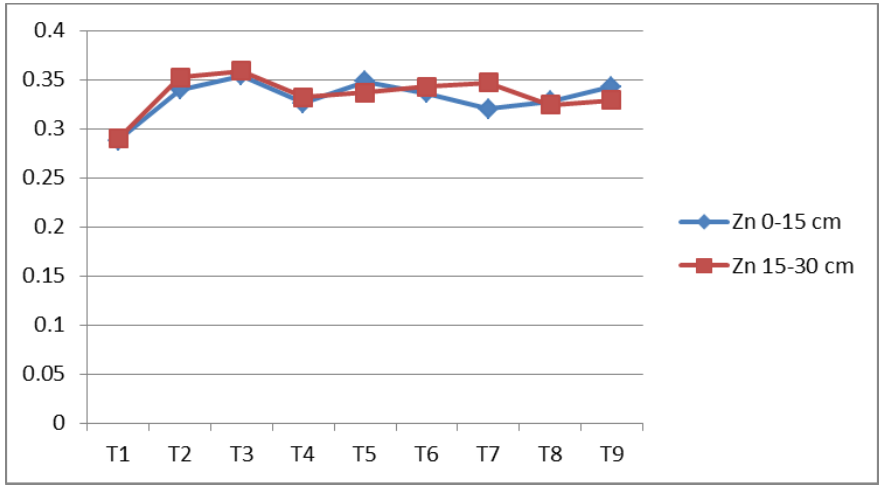

Fig. 5. Effect of different levels of NPK and Zn on Available Zn (mg kg^{-1}) of soil depth (0-15 and 15-30 cm)

recorded 324.78 kg ha^{-1} and 318.56 kg ha^{-1} found in treatment T_9 (NPK @ 100% + Zn @ 100 %) and minimum Available Nitrogen of soil was recorded 292.61 kg ha^{-1} and 288.34 kg ha^{-1} at soil depths 0-15 to 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0 %)] respectively. The nitrogen has its major significant role in completion of crop life cycle. Balanced use of nitrogen (N) fertilizers could play a pivotal role in increasing the yields. In addition to supplying a nutrient for plant growth, N application could enhance drought tolerance of plant to increase yield. Similar result has been recorded by Sharma et al., [22]; Javeed et al., [23].

3.2.5 Available phosphorus (kg ha^{-1})

The maximum Available Phosphorus of soil was recorded 21.03 kg ha^{-1} and 20.89 kg ha^{-1} found in treatment T_7 (NPK @ 100% + Zn @ 0 %) and minimum Available Phosphorus of soil was recorded 18.41 kg ha^{-1} and 17.45 kg ha^{-1} at soil depths 0-15 to 15-30 cm in treatment T_3 (NPK @ 0 % + Zn @ 100 %) respectively. The mean value of Available Phosphorus (kg ha^{-1}) of soil was found significant. Similar result has been recorded by Sharma et al., [22]; Javeed et al., [23].

3.2.6 Available potassium (kg ha^{-1})

The maximum Available Potassium of soil was recorded 210.45 kg ha^{-1} and 206.72 kg ha^{-1} found in treatment T_9 (NPK @ 100% + Zn @ 100%) and minimum Available Potassium of soil was recorded 185.24 kg ha^{-1} and 181.56 kg ha^{-1} at soil depths 0-15 to 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0%)] respectively. The mean value of Available Potassium (kg ha^{-1}) of soil was found significant. Similar result has been recorded by Sharma et al., [22]; Javeed et al., [23].

3.2.7 Available zinc (mg kg^{-1})

The mean value of Available Zinc (mg kg^{-1}) of soil was found significant. The maximum Available Zinc of soil was recorded 0.343 mg kg^{-1} and 0.329 mg kg^{-1} found in treatment T_9 (NPK @ 100% + Zn @ 100 %) and minimum Available Zinc of soil was recorded 0.288 mg kg^{-1} and 0.290 mg kg^{-1} at soil depths 0-15 to 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0 %)] respectively [24-29]. Similar result has been recorded by Tripathi et al., [30]; Bameri et al. [31] and Chaudhary et al. [32].

4. CONCLUSION

According to the trial, the fertilizers [Urea (46% N), + SSP (16% P_2O_5), + MOP (60% K_2O), + ZnSO4 (36.5% Zn)] used at different levels of NPK and Zn from different sources produced the best results in treatment T_9 (NPK @ 100% + Zn @ 100%), which was followed by treatment T_8. In T_9, the soil health parameters retained the appropriate soil properties. Therefore, for increased farm revenue and sustainable agriculture, it might be advised that farmers receive the finest combination treatment (T_9).

ACKNOWLEDGEMENT

I am grateful for ever-inspiring guidance, constant encouragement, keen interest and scholarly comments and constructive suggestions throughout the course of my studies and investigation from head of the department and staff, department of soil science and agricultural chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ghosh K, Swaroop N, Thomas T, Jadhav R. Soil Physico-chemical Properties as Influenced by Combined use of NPK and zinc at Varying Levels under black gram (*Vigna mungo* L.) Cultivation in an inceptisol of Prayagraj, Uttar Pradesh, India. International Journal of Plant & Soil Science. 2022;34(22):1172-82.
2. Thakur RK, Bisen NK, Shrivastava AK, Rai SK, Sarvade S. Impact of integrated nutrient management on crop productivity and soil fertility under rice (*Oryza sativa*)-chickpea (*Cicer arietinum*) cropping system in Chhattisgarh plain agro-climatic zone. Indian Journal of Agronomy. 2023;68(1):9-13.
3. Rao S, Tilak A Biochemical Methods for Agricultural Sciences. New Delhi: Wiley Eastern Limited. 1977;26-7.
4. Balasubramanian. Role of phosphorus on the interaction of vesicular arbuscular mycorrhiza (Glomusmosseae) and root-knot nematode (*Meloidogyne incognita*) on black gram (*Vigna mungo*). Indian Journal of Nematology. 1999;29(1):105-8.

5. Gangwar A, Jadhav TA, Sarvade S. Productivity, nutrient removal and quality of urdbean varieties planted on different dates. Bioinfole. 2013;10(1A):139-42.
6. Pathariya P, Dwivedi BS, Dwivedi AK, Thakur RK, Singh M, Sarvade S. Potassium balance under soybean–wheat cropping system in a 44-year old long-term fertilizer experiment on a vertisol. Communications in Soil Science and Plant Analysis. 2022;53(2):214-26.
7. Hafeez Z, Khanif YM. Role of zinc in plant nutrition-A Review-American Journal of Experimental Agriculture. 2013;3(2):374-91.
8. Jackson ML. Soil chemical analysis Prentice Hall of India Ltd. New Delhi. 1958;219-21.
9. Wilcox LV. Electrical conductivity. Water Works Assoc. 1950;42(8):775-6.
10. Lindsay WL, Norvell WA. Development of DTPA soil test for zinc, iron, manganese and copper. Soil Science Society of America Journal. 1978;42(3):421-8.
11. Walkley A, Black IA. Estimation of soil organic carbon by the chromic acid titration method. Soil Sci. 1947;47:29-38.
12. Kumar J, Sharma P, Meena S. Physico-chemical properties of the soil, under the two forest plantation stands around Varanasi (U.P.), India; 2008.
13. Bhattacharya VP, Mani AK, Thilagvathi T. Effect of sources and levels of phosphorus and P solubilizers on yield and nutrient uptake in rainfed green gram. Annals of Arid Zone. 2004;40:43-8.
14. Hussain M, Tahir M, Majeed MA. Effect of zinc sulphate as soil application and seed treatment on black gram (*Vigna mungo* L.). Pakistan Journal Life Society Science. 2022;12(2):87-91.
15. Dangi A, Kumar S, Singh S, Omkar, Singh BP. Effect of phosphorus and sulphur fertilization on productivity and nutrient uptake of black gram. Ann Agric Res New S. 2020;35(1):54-7.
16. Azadi E, Rafiee M, Hadis N. The effect of different nitrogen levels on seed yield and morphological characteristic of mungbean in the climate condition of Khorramabad. Annals of Biological Research. 2013;4(2):51-5.
17. Amruta N, Devaraju PJ, Mangalagowri Kiran SP, Ranjitha HP, Kalavati P. Effect of integrated nutrient management and spacing on seed quality parameters of black gram cv. Lbg-625 (rashmi). Journal of Applied and Natural Science. 2017;8(1):340-345.
18. Chandrakar K, Verma SK, Dubey S, Kesari R. Yield gap analysis of black gram through front line demonstration under rainfed condition. Int J Chem Stud. 2018;6(4):3173-6.
19. Jha DP, Sharma SK, Amarawat T. Effect of organic and inorganic sources of nutrients on yield and economics of black gram (*Vigna mungo*) grown during Kharif. Agric Sci. 2015;35(3):224-8.
20. Meena BL, Ram B. Integrated Nutrient Management in black gram under Rainfed Condition. Int J Recent Sci Res. 2016;7(10):13875-94.
21. Habib A, Ali A, Akhtar J, Yasin M. Effects of phosphorus in combination with rhizobium inoculation on growth and yield parameters of black gram (*Vigna mungo* L.). Crop Environ. 2018;1:53-6.
22. Sharma SN, Prasad R, Shivay YS, Dwivedi MK, Kumar S, Kumar D. Effect of rates and sources of phosphorus on productivity and economics of black gram as influenced by crop-residue incorporation. Indian Journal of Agronomy. 2009;54(1):42-6.
23. Javeed A, Gupta M, Gupta V. Effect of graded levels of NPK on growth, yield and quality of black gram under subtropical conditions. *SSARC* International Journal of Management. 2017;3(1):1-8.
24. Fisher RA. Statistical methods and scientific induction. J R Stat Soc S. 1960;17:69-78.
25. Muthuvel P, Udayasoorian C, Natesan R, Ramaswamy PP. Introduction to soil analysis. Coimbatore: Tamil Nadu Agricultural University-641002; 1992.
26. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate ($NaHCO_3$). Dairy Australia [Circular]. 1954; 939:1-19.
27. Sarvade S, Gautam DS, Upadhyay VB, Sahu RK, Shrivastava AK, Kaushal R et al. Agroforestry and soil health: an overview. J Int Dev, I, Agroforestry for Climate Resilience and Rural Livelihood Jodhpur, India: Scientific Publishers India. 2019: 275-97.
28. Subbiah BV, Asiija EC. A rapid procedure for estimation of available nitrogen in soil. Current Science. 1956;25(8):259-60.
29. Toth SJ, Prince AL. Estimation of cation exchange capacity and exchangeable Ca, K and Na content of soil by flame

photometer technique. Soil Sci. 1949;67 (6):439-46.

30. Tripathi HC, Pathak RK, Kumar A, Dimree S. Effect of sulphur and zinc on yield attributes, yield and nutrient uptake in black gram (*Vigna mungo* L.). Annals of Plant and Soil Research. 2011;13:134-6.
31. Bameri M, Abdolshahi R, Mohamadi NG, Yousefi K, Abatabaie SM. Effect of different microelement treatments on black gram (*Vigna mungo* L.) growth and yield. International Research Journal of Applied and Basic Sciences. 2012;3:219-23.
32. Chaudhary S, Singh H, Singh S, Singh V. Zinc requirement of black gram (*Vigna mungo* L.)-wheat (*Triticum aestivum*) crop sequence in alluvial soil. Indian Journal of Agronomy. 2014;59(1):48-52.

© 2023 Choudhary et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/100833